THURSDAY, JULY 24, 1884

THE CONSTRUCTION OF ORDNANCE

A Treatise on the Application of Wire to the Construction of Ordnance. By James Ackman Longridge, M.I.C.E. (London : Spon, 1884.)

ABOUT thirty years ago, during the raging of the Crimean war, special attention began to be directed towards the improvement of our artillery. The old Board of Ordnance was abolished. The manufacturing departments at Woolwich were put under the control of a newly created Minister of War. That able and high-minded officer, Colonel F. M. Eardley-Wilmot, R.A., was appointed Superintendent of the Gun Factories, July 1855. He commenced his work in a thoroughly sensible and practical manner, and pursued his inquiries for suitable materials for guns both at home and abroad. He was ready to adopt anything, new or old, provided it was of the right sort. Sir H. Bessemer has remarked : "My early progress was known to only a few scientific men, among whom was Colonel Eardley-Wilmot, R.A., who took great interest in the invention." But in the summer of 1859 it was decided to adopt the Armstrong breech-loading system, and in November 1859 Colonel Eardley-Wilmot was requested to resign his post at the Gun Factories, to make room for Mr. (now Sir W.) Armstrong.

The 12-pounder Armstrong breech-loading field-guns appear to have given satisfaction, and the authorities at once proceeded to manufacture 110-pounders on the same system without exercising due caution, as explained by General Peel in his letters to the *Times* about September 1868. For, he says, the following sums were voted "for the purchase and manufacture of warlike and miscellaneous stores :—

In 1860-61 ... ... £2,830,625 ; and
In 1861-62 ... ... £3,006,049

a great portion of which was for the 110-pounder Armstrong guns, which had been adopted into the service without any sufficient trial of them." Among other things, the vent-pieces failed, no matter of what material they were constructed. All the while the nation had to abide strictly by the terms of its bargain—it had adopted the gun, and it must take the consequences. We have never heard that any variation in the principle of the invention was tried with a view to relieve the gun of the excessive pressure at the breech. It was said that there was a contraction of the bore just before the seat of the shot, so that there could be little doubt that the whole of the quick-burning powder then in use would be converted into gas before the projectile moved forward any appreciable distance. Something must therefore yield, and that was generally the vent-piece. Before abandoning the system it would not have cost much to take some disabled gun and remove the chief part of the obstruction to the initial motion of the shot. But the 110-pounders had failed, and there was end of the system—according to the decision of its own friends. But it will be seen that at least one system employing lead-coated projectiles of about 300 lbs. in weight was made to succeed.

The authorities then turned their attention to *muzzle*-loaders, with which they were more successful. Although they now used studded shot, they were careful to avoid all needless obstruction to the *initial* motion of the shot by the use of an increasing twist in the rifling. Also the high initial tension of the powder gas would in this case find some relief from windage.

About the year 1869 the Prussian Government instituted a comparative trial between the English 9-inch muzzle-loading gun and the 9¼-inch breech-loading gun of Krupp. Different opinions have been expressed respecting the fairness with which this competition was conducted. But this much must be said in favour of the decision arrived at, that the Prussians seem to have abided by it, and that they have not come to England to purchase muzzle-loaders constructed on the iron coil system. The striking fact was that Krupp could construct breech-loading guns to fire 200 to 300 lb. lead-coated projectiles from a 9¼-inch breech-loading gun with safety, whereas the Woolwich breech-loading guns failed with similar shot of 110 lbs. with a bore of about 7 inches.

Since that time breech-loading has ceased to be looked upon as an impossibility. We even learn incidentally that we have ships armed with guns constructed on that system.

About 1865 the Committee on Explosives was appointed, who continued their labours throughout many years. We are not aware that details of their observations, made with the chronoscope and crusher gauges, were ever published *in extenso*. So long as this remains the case, the conclusions of the Committee can never be completely accepted. But so many contradictory observations have been published that we are compelled either to doubt the results given by the crusher gauge or to suppose that the forces developed by fired gunpowder are liable to great variation, even where the initial velocity of the shot is the same. Observations with the chronoscope we put aside as of no value in obtaining an accurate measure of the forces, which vary rapidly, and, acting upon a body at rest, generate a high velocity in a space of 10 or 20 feet. Observations of that kind are only valuable when the force affecting the motion changes by slow degrees.

Throughout all these changes the Woolwich system has been in the main the Armstrong system of coils of wrought iron for both breech- and muzzle-loading guns, while the recommendations of steel by Krupp and Whitworth have been set aside partly on the score of expense. But now there are indications that the Woolwich system of coiling is not considered to be quite satisfactory.

Mr. Longridge says :—"Since 1862 millions upon millions have been spent, and we are now told that we are on the eve of a new epoch of expenditure, that the great array of weapons which we have provided are no longer up to the mark, and millions upon millions must again be disbursed before the nation is properly armed" (p. 2).

This seems therefore to be a favourable opportunity for the official consideration of Mr. Longridge's system of applying wire to the construction of heavy ordnance. No other system allows of the tension being so nicely and so readily adjusted. Mr. Longridge appears to have been the first to advocate this system of constructing guns, for so early as 1860 he presented a paper on the subject to the Institution of Civil Engineers. When he first applied

to the Government, the objection to his proposals was their extreme novelty, but later on he was told that there was no novelty in the principle of his designs!

Mr. Longridge states the problem to be solved in the following satisfactory terms:—

"Suppose a coil of wire situated near to the inner tube of the gun. It is laid on under a certain tension, but its state is altered by each successive coil which comes over it, and when the gun is completed it is no longer in tension but in compression.

"There is in a finished gun a certain distance from the centre of the bore at which the wire is in a neutral state; it is neither in tension nor in compression. All the wires proceeding outwards from this point are in a state of tension varying, according to a definite law, according to the distance from the centre of the gun. All those proceeding inwards are in a state of compression, as is also the inner tube on which they are coiled.

"In a gun thus constructed the aggregate of all the tensions is exactly equal to that of the compressions whilst the gun is at rest, but when the strain of the explosion is brought into action the state of each wire is altered, all the compressions are reduced and eventually changed to tensions, and all the tensions increased; and, in a gun properly constructed, if the pressure inside were increased to the bursting point, every wire would be strained to its maximum tensile force, and would give way at the same time" (p. 15).

Afterwards Mr. Longridge gives elaborate calculations of the tension proper for each coil of wire.

The system of "chambering" large guns is now in use at Woolwich, Elswick, and Essen, but it appears most objectionable. We quite agree with Mr. Longridge, that "chambering is a poor and inefficient expedient for lengthening a gun at the cost of its durability." He found "that in the case of the 38-ton 12-inch gun the result of chambering out to 14 inches was to reduce the length of the charge from 27 to 20 inches . . . and that this would *cæteris paribus* increase the velocity of the shot about 7 or 8 feet per second" (p. 17). In such a case the mere chambering would give an increased longitudinal strain of nearly 820 tons in the chamber, allowing a pressure of 20 tons per square inch to the powder gas, while the tendency to burst the coil would be increased in the proportion 6: 7, or nearly 17 per cent. The Committee on Explosives profess to have discovered a so-called "wave action" which may or may not exist in guns fired under the same conditions. And it is claimed for "chambering" that it (1) gives a higher initial velocity, and (2) prevents the abnormal very high local pressures induced by long cartridges. In the case mentioned by Mr. Longridge 7 inches was the gain in the space through which the powder gas propelled the shot. But the charge being in a more compact form, only 20 inches long, would probably explode more rapidly than it would in the bore 27 inches long, and consequently the powder gas propelling the shot at corresponding points in the bore would be greater with the chambering, and consequently in that case the initial velocity of the shot might be expected to be greater, especially with the increment of 7 inches in the useful length of the bore. But it is difficult to imagine in what way chambering could reduce the stress upon the gun. We have found by calculation what would be the lengths of the following guns, in order to allow the same internal volume:—

	ft.	in.	
71-ton Krupp gun, chambered	32	10	long.
,, ,, unchambered	33	11	,,
80-ton Woolwich, chambered	26	9	,,
,, ,, unchambered	28	1	,,
100-ton Armstrong, chambered	32	8	,,
,, ,, unchambered	33	10	,,

From this it appears that the saving in total length of gun due to chambering is not great.

The process seems to have been this. After much trouble guns were manufactured which with a uniform bore and slow-burning powder stood tolerably well. In order to obtain an increased initial velocity the gun was chambered and therefore weakened. Sir W. Armstrong says that the calculated strength of his 100-ton chambered gun, which failed, was "far in excess of what a normal pressure would demand." And then he goes on to state, March 1880, that "Nothing, in fact, wants investigation so much as this powder question" (*Proceedings* of the R.A. Institution, Woolwich, vol. xi. p. 197). If chambering is to be profitably used it appears that it will be necessary to adopt steel and abandon coiling—both wire and wrought iron.

As a uniform bore gives the strongest form of gun, it appears to be very desirable to obtain a slow-burning powder less bulky than that now in use. But if that be not possible, we would either slightly lengthen the gun or use a powder a very little more energetic than that now in use, and just sufficient to compensate for a want of chambering.

Mr. Longridge quotes the following remark of Messrs. Noble and Abel on air-spacing:—"In cases where there is a considerable air-space between the charge and the projectile, it has been found that the energy developed in the projectile is materially higher than that due to the expansion of the powder gases through the space traversed by the projectile, and the cause of this appears to us clear.

"When the charge is ignited at one end of the bore, and the ignited products have to travel a considerable distance before striking the projectile, these ignited products possess considerable energy, and a portion of this energy will be communicated to the projectile by direct impact" (p. 110).

Well may Mr. Longridge exclaim: "With all respect to these gentlemen, we are quite unable to accept this explanation." The explanation we have to offer is that when a moderate air-space is left there will be a delay in the initial motion of the shot, and consequently the explosion of the charge for every position of the shot will have proceeded further than if there had been no air-space, and consequently the pressure of the powder gas will on the whole be increased. But, on the other hand, there will be a slight loss of velocity, since the powder gas acts on the projectile through a slightly reduced length of bore corresponding to the air-space.

We have never made experiments on the pressure and action of fired gunpowder. But we hold that with "chambering" and "air-spacing," using the same powder, the gun must be distressed, if by these means any sensible addition of initial velocity of the shot is obtained.

Mr. Longridge appears with reason to recommend the

adoption of a uniform twist of rifling, now slow-burning powder is used. The increasing twist of rifling was very probably effective in saving the gun when quickly-exploding powder was employed. But the importance of an increasing twist of rifling decreases as the action of the powder gas is rendered more nearly uniform. If the pressure driving the projectile throughout could be made perfectly uniform, then a uniform twist would exert a constant force to produce rotation.

Mr. Longridge says :—"So long ago as 17th March, 1860, the then Secretary of State for War, in his speech on the Army Estimates, said that 'these experiments proved that they had been wrong in using powder of so quick a detonating nature for artillery practice, and especially for rifled cannon, which required a weaker and slower powder than in the other cases" (p. 113). And twenty-four years later, March 20, 1884, the Secretary to the Admiralty said: "The old breech-loader had been found to be of no more use than a muzzle-loader, and the Government had adopted a gun twice as long as the old form of breech-loader." It is not very clear what all this means, but it is plain that vast sums of money will be required to provide long guns. Twenty years ago it might have been determined what effect every additional foot in length of a gun had in imparting increased initial velocity and increased steadiness to projectiles; but something more than the "rule of thumb" would be required to accomplish this.

England has of late come to acknowledge the value of technical training, and has shown a readiness to take a lesson from Continental nations. Is it not natural to suppose that some training of this kind might be found useful in settling the proportions of our guns, and in other matters of the same kind?

We think that Mr. Longridge has made out his case, and that his system deserves a fair trial in comparison with other promising systems. It has already been deemed worthy of a partial trial at Elswick, in France, and America. Experimental guns on different promising systems might in the first case be constructed of small calibre, and adapted to fire the service projectiles. If these proved satisfactory, then proceed to construct larger guns, and finally let that system survive which was found best fitted for its purpose. F. B.

OUR BOOK SHELF

A History of British Birds. By the late William Yarrell, V.P.L.S., F.Z.S. Fourth Edition. Revised to the end of the second volume by Alfred Newton, M.A., F.R.S., continued by Howard Saunders, F.L.S., F.Z.S. Parts XXI.-XXIV., January to July, 1884. (London: Van Voorst.)

ALTHOUGH, as we have said in a former notice of this work, it was a great pity that Prof. Newton could not be induced to complete his revised edition of Yarrell's well-known "History of British Birds,"—a subject in which he is before all other living naturalists at home, there can be no doubt that the task has fallen into good hands. Mr. Howard Saunders has not only completed a volume in about the same space of time that the former editor took to issue a single number, but has performed his work in a style to which, we think, little exception will be taken. The aim of Yarrell's "History of British Birds," we suppose, is to be sufficiently popular to be understood by all well-educated people, and at the same time to be thoroughly correct in scientific matters, so far as they are involved. As to Mr. Saunders' numerous remarks upon points of synonymy and distribution being entirely free from error, we should be very sorry to guarantee anything of the sort. But as we turn over the pages of his recent numbers, very few exceptional statements seem to present themselves, and most of these relate to what are to a certain extent matters of opinion.

Having finished his *Limicolæ* in Part XXI., Mr. Howard Saunders naturally proceeds to the Gaviæ, a part of his subject with which he is, as we all know, very familiar. An author who has worked out the Laridæ of the whole world in a thoroughly conscientious manner, and made this group his special study, is above all others qualified to prepare a special account of the "British" species. Of these Mr. Saunders recognises thirty as admissible into the list, though it is more than probable that this already large number will be still increased by the arrival in future years of stray individuals belonging to other species of this essentially wandering tribe of birds.

Congratulating our author on the accomplishment of the first volume of his portion of this excellent work, we may venture to express a hope that he will bring the long-delayed fourth edition of "Yarrell's Birds" to a speedy and satisfactory conclusion.

Bulletin of the United States National Museum. No. 19. "Nomenclator Zoologicus." By Samuel H. Scudder. 8vo. (Washington, 1882-1884.)

MR. SCUDDER'S "Nomenclator Zoologicus," which has been issued as No. 19 of the *Bulletins* of the United States National Museum, is not of a generally attractive nature, but will be of great use to working zoologists. It consists of two parts: the first of these, or "Supplemental List," contains the names of genera in zoology established previous to 1884, which are either not recorded or erroneously given in the previously issued Nomenclators of Agassiz and Marschall. To each generic name is added a reference to the work in which it is to be found. The second portion of Mr. Scudder's volume, or "Universal Index," contains an alphabetical index of all the names included in the "Supplemental List," together with those given in the Nomenclators of Agassiz and Marschall, and in the Indices of the Zoological Records. This second, most important part, contains about 80,000 entries, and, if correctly drawn up, as we have no reason to doubt is the case, will enable a naturalist who has recourse to it to determine at a glance whether any particular name has been already employed in zoology or not. All working naturalists will at once acknowledge the value of such an index as this, and will join us in thanking Mr. Scudder for having produced it. Could Mr. Scudder's index be magnified into a "Lexicon Zoologicum," giving the references to all the 80,000 terms in a single volume, a still more meritorious and useful work would be the result. Until this shall have been accomplished, it will still be necessary for a naturalist to refer to half a dozen or more different works in order to ascertain where any particular generic term has been employed in zoology.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Krakatão

I FORWARD a letter recently received from a former pupil, Dr. Stanley M. Rendall, which gives so graphic a description of the